

## Using a Float Coat for Preservation of Large-Volume Storage Systems

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Traditional water treatment methods pose several challenges to large-vessel preservation. The economics of continuous dosing and environmental restrictions concerning the disposal of treated water need to be considered. One solution to these challenges involves the application of an immiscible corrosion inhibiting oil partition on the water surface (henceforth referred to as a “float coat”). This article highlights the challenges of traditional preservation methods and examines the efficacy of one commercial float coat. Large vessel preservation is typically accomplished through one of two methods: chemical treatment of water during hydrotesting or heavy-duty epoxy coating systems. These treatment systems have proven to be effective. However, novel approaches to large vessel preservation provide an opportunity to overcome challenges involved with more traditional preservation methods.

**There are various water treatment methods available to protect large storage vessels from corrosion, including those used in the petroleum industry. This article describes common methods and presents testing information and conclusions about a coating technology that is cost-effective, environmentally friendly, and suitable for large vessel protection.**

### Preservation Methods

#### *Chemical Treatment*

Aboveground storage tanks (ASTs) in the petroleum industry come in a wide variety of sizes, ranging from modest sizes of 200 m<sup>3</sup> up to storage volumes in excess of 100,000 m<sup>3</sup>.<sup>1</sup> For even the most modest dosage rates of chemical treatment at 500 ppm, costs can exceed \$2.5 million USD for more than 115 m<sup>3</sup> of chemical treatment.

#### *Coatings*

Coatings can be separated into removable, or “temporary” coatings, and permanent coatings. After the application of either type of coating, the proper amount of cure time must be allowed for the coating to achieve peak performance. Typical recommendations call for one week of cure time. During this time, no maintenance or testing can be performed on coated areas, resulting in lost time and productivity.

For tanks with a 91.4-m diameter and 18.3-m wall height,<sup>1</sup> the total wall surface area is approximately 5,300 m<sup>2</sup>. Given a spread rate of 3.7 m<sup>2</sup> per liter, over 1,500 L of the coating are required, costing upwards of \$40,000. While removable or temporary coatings typically cost less than permanent coatings, the reapplication of any coating for long-term preservation would require significant labor cost for surface preparation and application. Finally, lost time (for product application and cure time) is also a considerable factor, resulting in lost profits.

#### *Waste Disposal*

Waste disposal and environmental concerns can be very large factors in determining the efficacy of any procedure whose

processes produce any amount of potentially hazardous chemical waste. The cost to properly dispose of “dirty water waste” ranges from \$0.04 to \$0.24 per cubic m<sup>3</sup>.<sup>2</sup> Given a tank size of 100,000 m<sup>3</sup>, waste disposal can add up to \$24,000 onto existing project costs. Though more modest-sized containers would significantly reduce the cost for waste disposal, this expense still remains a major consideration in the efficacy of any given treatment.

#### *Application of a Float Coat*

A float coat is a corrosion-inhibiting oil that is applied to a large-volume system during a typical hydrotesting process. The float coat, being a hydrocarbon-based product, floats on the surface of the water, allowing for a unique application using a much smaller volume of product than typical chemical additives.

The vessel floor and initial meter of wall height is sprayed with a layer of the float coat before any water is added to the system. Water is slowly added, until a point just below the initial spray treatment, so to avoid disturbing the applied float coat protective coating. The remainder of the float coat is applied to the top of the water layer. Hydrotesting is then carried out as normal with care to fill the system at such a rate that the float coat layer on the water's surface is not disturbed. As the hydrotest proceeds, the walls of the vessel are coated with the float coat and further recoated as the vessel is drained.

#### *Experimental Procedures*

Using a float coat has proven to be a viable preservation technique for ASTs and other large vessels during hydrotesting via

a number of laboratory studies as well as real-life application.

### *Laboratory Testing: Humidity Testing*

ASTM D1735<sup>3</sup> and D1748<sup>4</sup> conditions are standard accelerated weathering environments. Both of these environments were used to evaluate the corrosion resistance of the oil film in non-submerged situations such as the conditions experienced within an AST after a hydrotest and during preservation.

#### **ASTM D1735**

ASTM D1735 is a test that examines a coating's resistance to constant water fog in a warm environment. The temperature of the chamber is held at 38 °C (100 °F), and deionized (DI) water is continuously fogged into this space such that 1.0 to 3.0 mL is collected on an 80 cm<sup>2</sup> surface area every hour. Steel panels are cleaned, coated with the float coat, and drained prior to being placed in the test chamber 15 degrees from vertical. Significant corrosion is typically witnessed on control samples within one day, but the duration of testing is dependent on how long the test panels remain free of corrosion.

#### **ASTM D1748**

ASTM D1748 is a humidity test that examines a coating's resistance to high temperature and humidity. The temperature of the chamber is held at 48.9 ± 1.1 °C (120 ± 2 °F), and the panels are suspended by hangers designed so water does not drain from the hanger to the panel's surface. These hanging panels are then rotated through the chamber to allow every panel to experience identical conditions. Corrosion is typically witnessed on control samples within one hour, but the duration of testing is dependent on how long the test panels remain free of corrosion. This test was modified by using 0.063- by 2- by 4-in (1.6- by 51- by 102-mm) SAE 1008 cold-rolled steel panels and preparing the surface according to the procedure described in 8.2 through 8.3.6 without performing the heated solvent cleaning described in 8.3.7 through 9.2. Rather, the top edges of the

panels were protected after removal from the solvent referenced in Section 8.3.6 and the float coat was applied to the panel as described in Section 9.2.

### *Laboratory Testing: Immersion Testing*

Immersion testing was performed in a 3.5 wt% solution of sodium chloride (NaCl) in DI water. This solution was held in a cylindrical glass cell with a 5-in (127-mm) height and 2-in diameter. Two hundred grams of this solution were used in each test cell to ensure the full immersion of the tested steel panels (0.063- by 1- by 3-in [1.6- by 25- by 76-mm] SAE 1008 cold-rolled steel). Ten grams of preservative oil were added to each cell to build a substantially thick layer on the surface of the water. Pre-weighed steel panels were slowly lowered through the float coat into the test solution to ensure an even coating. These cells were placed into a 40 ± 2 °C oven for two weeks before being removed and left at ambient conditions (22 ± 2 °C) for 21 weeks. At this time the panels were removed, the oil residue was cleaned off with methanol, and oxides were cleaned from the surface via a 7.8 M hydrochloric acid (HCl) solution. The panels were examined for mass loss and the rate of corrosion was calculated using the following formula from ASTM G31<sup>5</sup> (Equation 2, Section 12.4) shown in Equation (1):

$$\text{Corrosion Rate (mpy)} = \frac{3.45 \times 10^6 \times W}{A \times T \times D} \quad (1)$$

where W represents the mass loss in grams, A is the panel surface area in cm<sup>2</sup>, T is the duration of the test in hours, and D is the metal density in grams per cubic centimeter (7.87 g/cm<sup>3</sup> for SAE 1008 steel). The corrosion rate reduction was also calculated by comparing the control sample to the test samples, as shown in Equation (2):

$$\text{Corrosion Rate Reduction} = 1 - \frac{R}{C} \times 100\% \quad (2)$$

where C represents the corrosion rate of the control sample and R is the corrosion rate of the test sample.

### *Laboratory Testing: Coating Thickness and Dosing Estimation*

Coating thickness and appropriate dosage were determined by constructing a ves-

sel in which to simulate the float coating process. A 5-gal (19-L) container was fitted with a ball valve near its base to act as a drain while a rubber hose, guided to the base of the container via a 1-in diameter polyvinyl chloride pipe, was used to siphon water from another 5-gal container. Four- by twelve-in (102- by 305-mm) SAE 1008 steel panels were suspended in the center of the vessel to act as stationary steel surfaces would in an actual application. The proper dosage was determined by considering the water surface area, monitoring the addition of oil until a consistent film formed on the water, and raising the water level to coat the suspended steel panels. When the coating applied evenly without breaking the oil surface as it was raised over the panel, the dosage was considered adequate for float coat application. After draining the water from the vessel and allowing excess oil to drip from the test panel's surface, the film thickness was evaluated with a standard wet film thickness (WFT) gauge.

### *Real World Analysis*

Float coating has been successfully used as an AST preservation method in the Middle East. This project provided affordable corrosion protection through the application of a float coat while hydrotesting the system. The float coat was applied with neither minimal disruption to normal application procedures nor any negative impact on any cured phenolic epoxy liners, typically used in tanks.

A water sample from the float coat system was submitted to a third-party chemical analysis firm for chemical testing. Analysis for several hazardous chemicals was performed, including dissolved metals, such as lead, mercury, and zinc, and several hazardous hydrocarbons, such as benzene, toluene, naphthalene, and others. Tests were carried out according to APHA 3120 B,<sup>6</sup> U.S. EPA SW 846/8260B,<sup>7</sup> and U.S. EPA SW 846/8081B<sup>8</sup> for various metals, volatile organic compounds, and organochlorine pesticides, respectively. Upon gaining disposal approval, hydrotest water was disposed of with minimal impact to normal operational procedures.

## Results

### *Laboratory Testing: Humidity Testing*

#### **ASTM D1735**

Product A was tested according to ASTM D1735 to assess its corrosion protec-



**FIGURE 1.** ASTM D1735 test results with Product A. The control panel is pictured on the far left.



**FIGURE 2.** ASTM D1735 test results with Product A. The control panel is pictured on the far left.



**FIGURE 3.** Image of the inside of the float coating test vessel. The vessel can accommodate several standard 4- by 12-in test panels (3- by 5-in test panels are pictured above).



**FIGURE 4.** Total view of the float coating test vessel. Test panel holder, funnel and tubing for bottom-up filling of the vessel, and drain spout can be seen.

tion capabilities where constant water fog is present. Treated 3- by 5-in SAE 1008 steel panels were tested for 500 h in the specified conditions before any corrosion was seen, as shown in Figure 1. In contrast, a control steel panel showed signs of corrosion within 24 h.

#### ASTM D1748

Product A was tested according to ASTM D1748 (with modifications noted above) to assess its corrosion protection in a constant condensing humidity environment. Treated steel panels were tested for over 1,950 h in the specified conditions before any corrosion was seen (Figure 2). In contrast, a control steel panel showed signs of corrosion within 24 h.

#### Laboratory Testing: Immersion Testing

Product A was tested in immersion conditions as noted above to assess the level of protection offered in a corrosive solution. As shown in Table 1, each panel that was treated with Product A witnessed a corrosion rate reduction of over 98%.

#### Laboratory Testing: Coating Thickness and Dosing Estimation

Immediately after application of Product A, a WFT gauge indicated a 175- $\mu\text{m}$  (7-mil) film thickness on the surface of the test panel. After being allowed to drain for 1 h, the film was reevaluated to find a WFT of less than 25  $\mu\text{m}$  (1 mil).

Through several trials, the necessary amount of product required to ensure a uniform coating thickness upon application was determined to be 5.5 L of Product A per  $\text{m}^2$  of cross sectional tank area. In the case of tanks with a non-constant cross sectional area (e.g., frustum-shaped tanks), the average cross sectional area should be used. Through similar trials the required amount of product to properly coat vessel walls was determined to be 1 L per 20  $\text{m}^2$ . The test apparatus is shown in Figures 3 and 4.

#### Real World Analysis

Select results from the elemental analysis testing of water used to apply Product A are provided in Table 2.

#### Conclusions

Traditional chemical treatment and epoxy coatings can be both expensive and time-consuming methods for protection and preservation of large vessels. In large volume systems, a float coat can offer a more economical corrosion protection



**TABLE 1. IMMERSION TEST RESULTS**

Sample	Treatment	Starting Mass (g)	Ending Mass (g)	Mass Loss (g)	Corrosion Rate (mpy)	Corrosion Reduction
1	Product A	23.8277	23.8234	0.0043	0.012	98.3%
2		23.8607	23.8567	0.0040	0.011	98.5%
3		23.8432	23.8381	0.0051	0.014	98.1%
4	Control	23.9134	23.6430	0.2704	0.73	N/A

solution than traditional chemical treatment by offering dosage rates based on surface area compared to costly dosage rates based on volume. Additionally, the minimally invasive application method can offer significant time savings when compared to traditional coating applications.

Humidity testing according to ASTM D1735 and D1748, and immersion testing based on ASTM G-31 showed excellent corrosion protection from the thin film left by Product A. Field application of the float coat product demonstrates the efficacy of these points. As shown in Table 2, this treatment does not impact the chemistry of the hydrotest water, allowing for water disposal to be carried out with only minimal disruption to normal disposal procedures and providing time and cost savings by significantly reducing or eliminating the expensive and lengthy process of handling large volumes of industrial waste.

The use of a float coat is an affordable and effective method for corrosion protection of large-volume vessels. Cost savings, time savings, and environmental considerations provide the basis for this novel treatment to vie with traditional preservation methods.

## References

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**TABLE 2. SELECT RESULTS FROM HAZARDOUS CHEMICAL TESTING<sup>9</sup>**

Chemical	Practical Quantification Limit (PQL)	Units	Result
Arsenic	0.09	mg/L	N/D(A)
Cadmium	0.15	mg/L	N/D
Chromium	0.1	mg/L	N/D
Lead	0.08	mg/L	N/D
Zinc	0.51	mg/L	N/D
Mercury	0.0005	mg/L	N/D
1,1-dichloroethene	6	µg/L	N/D
Chloroform	5	µg/L	N/D
Benzene	4	µg/L	N/D
Toluene	5	µg/L	N/D
Chlorobenzene	6	µg/L	N/D
Styrene	5	µg/L	N/D
Naphthalene	9	µg/L	N/D
4,4'-DDT	0.16	µg/L	N/D
Endrin	0.38	µg/L	N/D

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